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FEDERAL AVIATION ADMINISTRATION WASHINGTON D C FLIGHT--ETC F/G 21/4
DIRECTED SAFETY INVESTIGATION - USE OF HIGHER LEADED FUELS IN E--ETC(U)
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DIRECTED SAFETY INVESTIGATION
USE OF HIGHER LEADED FUELS IN ENGINES
ORIGINALLY CERTIFICATED FOR USE WITH GRADE 80
AVIATION GASOLINE



JANUARY 1977

FINAL REPORT

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Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Flight Standards Service
Washington, D.C. 20591

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Technical Report Documentation Page

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16. Abstract A Directed Safety Investigation (DSI) was conducted to determine: (1) the extent of maintenance required as a result of using Grade 100LL or Grade 100 aviation gasoline in engines originally certificated for use with Grade 80 gasoline; and (2) the extent of availability of Grade 80 gasoline. The DSI shows: (1) that an increase in the maintenance of spark plugs and valves is required when the higher leaded fuels are used in the Avco Lycoming O-320 and the Teledyne Continental Motors O-200 engines which were certificated for use with Grade 80 gasoline; (2) that Grade 80 aviation gasoline is not available in many places in the United States; and (3) that even though Grade 80 is available in some areas not all the fuel suppliers dispense it.		14. Sponsoring Agency Code	
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PREFACE

Grateful acknowledgement is made to the many people who assisted in this Directed Safety Investigation and without whose help it could not have been conducted. These people include the industry representatives who assisted in its preparation and organization. It also includes FAA personnel at the Flight Standards National Field Office, Oklahoma City and in the Flight Standards and General Aviation District Offices throughout the United States. Finally, and most of all, it includes those people in the General Aviation Community who answered our questions.

ACCESSION FOR	
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DCS	Blue Section <input type="checkbox"/>
UNANNOUNCED	Justification <input type="checkbox"/>
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DIRECTED SAFETY INVESTIGATION
USE OF HIGHER LEADED FUELS IN ENGINES
ORIGINALLY CERTIFICATED FOR USE WITH
GRADE 80 AVIATION GASOLINE

INTRODUCTION

Increasing prices for crude oil, escalating production costs, and increasing competition by heating and power generation needs and industrial uses for plastics have resulted in a distribution of about 5-8 percent of the total domestic petroleum demand to air transportation. Of that small share, aviation gasoline is but 5 percent, or 0.25-0.40 percent of the total domestic petroleum demand. Because aviation gasoline demand has decreased steadily to a relatively insignificant portion of the oil industry's total market, that industry has sought to improve its economics by standardizing on a single grade of aviation gasoline suitable for all current and projected piston aircraft engines. Grade 100LL is the result of that decision, and one by one several oil companies have stopped producing Grade 80 (formerly 80/87) gasoline. Now there are many places in the United States at the time of the survey where Grade 80 fuel cannot be obtained as indicated on Figure 1.

Traditionally reciprocating engines have been certificated for a specific grade of fuel which was identified as the minimum grade to be used. The usual practice has been to use the next higher grade of fuel whenever the minimum grade could not be obtained. As long as the Grade 80 gasoline was generally available, the higher grade fuel was used only occasionally.

This occasional use of the higher grade fuel rarely, if ever, caused any problems. It was only after the Grade 80 was no longer available, and the higher grade fuel had to be used exclusively that problems began to be reported.

The Federal Aviation Administration (FAA) anticipated the situation and in October 1971 issued Advisory Circular No. 91-33 entitled, "Use of Alternate Grades of Aviation Gasoline for Grade 80/87." This advisory circular warns of the need for increased maintenance when the higher grade fuel is used exclusively because of the increased amount of tetraethyl lead (TEL) in that fuel. By mid-1975 the reports of problems began to be received regularly, and articles discussing the situation were being published by many aviation magazines. These articles resulted in so many letters that it was difficult to determine whether problems had actually been experienced or whether fears that problems would be experienced were being reported. As a consequence the FAA, early in 1976, undertook a Directed Safety Investigation (DSI) in an attempt to determine the nature and magnitude of the problem and whether safety is impacted. The FAA notice setting up the DSI is enclosed as Appendix I. The questionnaire used to obtain the desired information was included as an appendix to that notice and has been reproduced here as Appendix II.

THE DIRECTED SAFETY INVESTIGATION

FAA Flight Standards and General Aviation District Office Inspectors were requested to contact personally "as many Pilots/Owners/Operators and Fixed Base Operators (FBO) as possible." The investigation was intended to determine:

1. The availability of Grade 80 fuel.
2. The maintenance "norms" for engines run on the three different grades of fuel--80, 100LL and 100 aviation gasoline.
3. If the local supplier has Grade 80 fuel available even though the FBO does not store or dispense it.

DISCUSSION OF RESULTS

Table I is a summary of the replies received during the investigation. The total number of reports received was 1146. This number covered 824 aircraft, 1021 engines and 1108 Fixed Base Operators. Also included on Table I are the specific engines for which reports were received and the approximate population of each of those engines. It is readily apparent from this table that sufficient reports to permit a reliable analysis were received for only two engines. These engines are the Avco-Lycoming O-320 and the Teledyne Continental Motors O-200. Both these engines were certificated specifying Grade 80 as the minimum grade fuel to be used. Also these two engines represent the largest population of engines now in use on Grade 80 fuel. It was decided in view of the small number of reports on the other engines to confine the analysis to the O-320 and O-200 engines. Accordingly, the conclusions reached in this report may not necessarily apply to other engines.

Fuel Availability and Distribution - Table II shows the fuel availability from and distribution among the Fixed Base Operators, other than Fixed Base Operators and All Operators Dispensing Fuel. The most significant item of information in this table is the number of fuel

suppliers who can still obtain Grade 80 aviation gasoline but who do not do so. Approximately 12 percent of all the fuel suppliers questioned can get Grade 80 fuel, but they do not do so. Approximately 17 percent of the Fixed Base Operators questioned can get Grade 80 fuel but do not do so. The investigation did not determine the reasons for this situation.

The geographical distribution of Grade 80, 100LL and 100 are shown on Figures 1, 2, and 3 respectively. Figure 1 shows large portions of the United States where Grade 80 is not available. This trend may be reversing, since on January 12 the Exxon Company announced that they will once again be making Grade 80 fuel available.

Effects of Using Various Fuels - The effects of using the various fuels is shown on Figures 4 through 9. In each figure the ordinate is "Percentage of Engines Reported" and is the percentage of the number of engines reported to be using the designated fuel. Table III shows the number of reports received on Avco-Lycoming O-320 and Teledyne Continental Motors O-200 engines for the various fuel utilizations. Therefore, as an example, if a figure indicates 11 percent for engines operated exclusively on Grade 80 fuel, the 11 percent represents 8 engines. That is 11 percent of the 73 engines shown on Table III as using Grade 80 fuel exclusively. The figures are plotted with the amount of TEL increasing toward the right along the abscissa. In Figures 6 through 9 this plotting arrangement assumes: (1) that when Grade 80 is not used exclusively, Grade 100LL is used; (2) that when Grade 100LL is not used exclusively, Grade 80 is used; and (3) that when Grade 100 is not used exclusively Grade 100LL is used. This assumption may be incorrect and may account for some

discrepancies apparent in some of the figures.

Figure 4 shows the effect of using the designated fuel exclusively. This figure shows that although there are problems experienced even on Grade 80 fuel, the number of problems increases significantly with an increase in the TEL content in the fuel used.

Figure 5 displays three intake valve problems, sticking, seating and erosion. This figure shows that so long as Grade 80 fuel is used exclusively, or more than 50 percent, few intake problems are experienced. Higher leaded fuels, however, cause a larger number of sticking and erosion problems, particularly when Grade 100 is used exclusively.

Figure 6 displays the same three valve problems for exhaust valves. Here again, use of Grade 80 fuel, more than 50 percent, results in few exhaust valve problems. But the use of higher leaded fuels causes a significant increase in valve problems, particularly sticking and erosion.

Figure 7 shows the tendency toward spark plug fouling with an increase in the TEL. The fifth bar in this figure shows a decrease in plug fouling tendency. This apparent discrepancy may be explained by lack of detailed information on this bar. Although Grade 100 fuel was used over 50 percent of the time, the fuels used the remainder of the time and the actual amount of their use were not determined.

Figures 8 and 9 show the reasons for intake and exhaust valve maintenance respectively, and again indicates an increase with TEL.

Those problems have definitely been characterized by the effects of the increased lead content of Grade 100LL. Engines have always been faced with erosion problems of valves and seats due to the lead compound

action. Engines designed for use of Grade 80 incorporated design features and materials which could tolerate the lead erosion for a normal overhaul life. When fuel with four times the lead content such as Grade 100 is used, then it rationally follows that the lead erosion problems are going to be encountered sooner than the normal overhaul period for Grade 80. This is exactly what the DSI and other analysis has supported.

To combat the problems, which is a matter of economics involving costs for more maintenance, the engine manufacturers are striving to build engines tolerant of the higher lead content for periods between normal overhaul. Modification parts are available from Continental and Lycoming as an effort to extend valve life on existing engines. Certain operating techniques such as early leaning and avoidance of long periods of idle can also effectively increase an engine's tolerance for Grade 100LL.

The nature of the valve problems operating on Grade 100LL is progressive; that is, early symptoms are apparent long before catastrophic engine failure. Emphasis on inspection wherein compression checks provide advance warning of valve problems is definitely in order for Grade 100LL users in engines designed for Grade 80.

The questionnaire used to obtain the desired information included a section for comments. A review of these comments reveals that none of the operators reported any safety problems.

Other areas of interest covered by the questionnaire were inconclusive because of insufficient data. These areas included type of flying, operational procedures and the use of improved intake and exhaust valves.

It should be remembered that the information from which the data is reduced is collected from individuals by a preselected set of questions. As

such, it is subject to the opinions, biases and view points of the individual answering the questions. It should also be remembered that the situation under consideration is a changing situation. At best, this DSI describes to some degree the situation as it existed in June and July 1976 when the survey was conducted. The situation is probably different at the time of this writing, December 1976. It is well known that some of the problems encountered are not caused by TEL alone. The FAA has received reports from several independent sources indicating that a change in the brand of fuel has significantly reduced the problem in some instances.

The fuel specification sets the maximum amount of TEL. It may be that some brands of fuel have less TEL than others. If so, this fact may cause different effects. Finally, even on Grade 80 fuel some engines have more problems than others. It appears, therefore, that some engine design features may aggravate the problems experienced with TEL more than other features.

CONCLUSIONS

1. The information reported for the Avco-Lycoming O-320 and the Teledyne Continental Motors O-200 engines clearly indicates an increase in spark plug and valve maintenance is required with a change from Grade 80 to Grade 100LL aviation gasoline.

2. Although insufficient information was obtained to permit a firm analysis, other low compression engines may also require increased spark plug and valve maintenance with increased use of fuels with more TEL than Grade 80.

3. The information supplied does not indicate a safety problem so much as an economic problem resulting from the increased maintenance required.

TABLE I
SUMMARY OF ENGINES SURVEYED

1. TOTAL NUMBER OF REPORTS RECEIVED			1146
AIRCRAFT REPORTS			824
ENGINE REPORTS			1021
FIXED BASE OPERATORS			1108
2. ENGINE MODELS REPORTED			
<u>MAKE</u>	<u>MODEL</u>	<u>REPORTED</u>	<u>APPROXIMATE POPULATION</u>
Jacobs	-----	1	425
Pratt & Whitney	R985	48	4860
	R1340	1	1830
Franklin	6A4150	3	1208
Teledyne Continental Motors	E 185	4	2324
	O 200	342	16043
	O 300	32	11131
	GO 300	2	
	IO 360	2	2938
	O 470	55	26284
	IO 470	24	
	IO 520	38	19274
	TSIO 520	18	
	GTSIO 520	15	
Avco-Lycoming	O 235C	31	5162
	O 290	1	3479
	O 320	300	32742
	IO 320	11	
	O 360	37	20698
	IO 360	36	
	HO 360	1	

SUMMARY OF ENGINES SURVEYED (con't.)

<u>MAKE</u>	<u>MODEL</u>	<u>REPORTED</u>	<u>APPROXIMATE POPULATION</u>
Avco-Lycoming	GO 435	1	1621
	VO 435	6	
	TVO 435	1	
	GO 480	4	1919
	GSO 480	2	
	IGSO 480	2	
	O 540	9	17851
	IO 540	24	
	VO 540	6	
	IGSO 540	2	
	ITO 540	2	
	TSIO 540	2	
	TIGO 541	2	947

TABLE II

FUEL AVAILABILITY AND DISTRIBUTION

Fixed Base Operators
803 Surveyed

	<u>Available to</u> <u>No. of Operators</u>	<u>Dispensed by</u> <u>No. of Operators</u>	<u>Not Dispensed</u> <u>No. of Operators</u>
Grade 80	296 (36.86%)	246 (30.64%)	50 (16.88%)
Grade 100LL	587 (73.1%)	514 (64.01%)	73 (9.09%)
Grade 100	279 (34.74%)	207 (25.78%)	72 (25.80%)

Other Than Fixed Base Operators
289 Surveyed

Grade 80	102 (35.29%)	16 (5.45%)	86 (29.76%)
Grade 100LL	197 (68.17%)	35 (12.11%)	162 (56.05%)
Grade 100	135 (46.71%)	36 (12.46%)	99 (34.26%)

All Operators Dispensing Fuel
1092 Surveyed

Grade 80	398 (36.47%)	262 (23.99%)	133 (12.18%)
Grade 100LL	775 (70.97%)	549 (50.27%)	235 (21.52%)
Grade 100	414 (37.91%)	243 (22.25%)	171 (15.66%)

TABLE III
NUMBER OF ENGINES REPORTED
TO BE USING DESIGNATED FUEL

Avco Lycoming 0-320 and Teledyne Continental Motors 0-200

Grade 80 fuel less than 50 percent	485 engines
Grade 80 fuel more than 50 percent	*164 engines
Grade 80 fuel exclusively	73 engines
Grade 100LL fuel less than 50 percent	242 engines
Grade 100LL fuel more than 50 percent	*400 engines
Grade 100LL fuel exclusively	367 engines
Grade 100 fuel less than 50 percent	577 engines
Grade 100 fuel more than 50 percent	* 62 engines
Grade 100 fuel exclusively	25 engines

*The number of engines indicated as using the designated fuel "more than 50 percent" includes the number of engines indicated as using the designated fuel "exclusively."

AVAILABILITY AND DISTRIBUTION
GRADE 80 FUEL
803 FIXED BASE OPERATORS
FAA REGIONAL BOUNDARIES

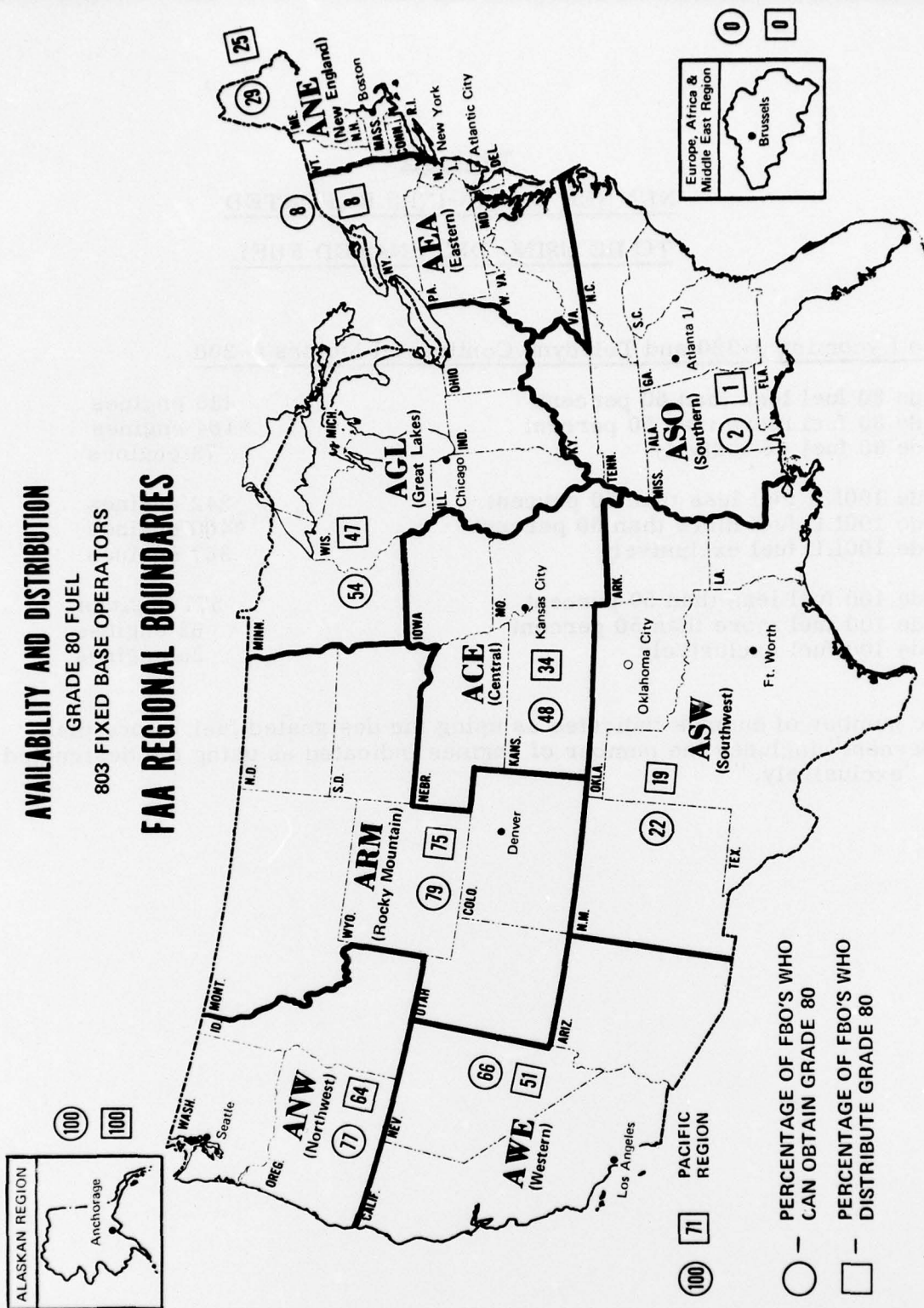


FIGURE 1

AVAILABILITY AND DISTRIBUTION
GRADE 100LL FUEL
803 FIXED BASE OPERATORS
FAA REGIONAL BOUNDARIES

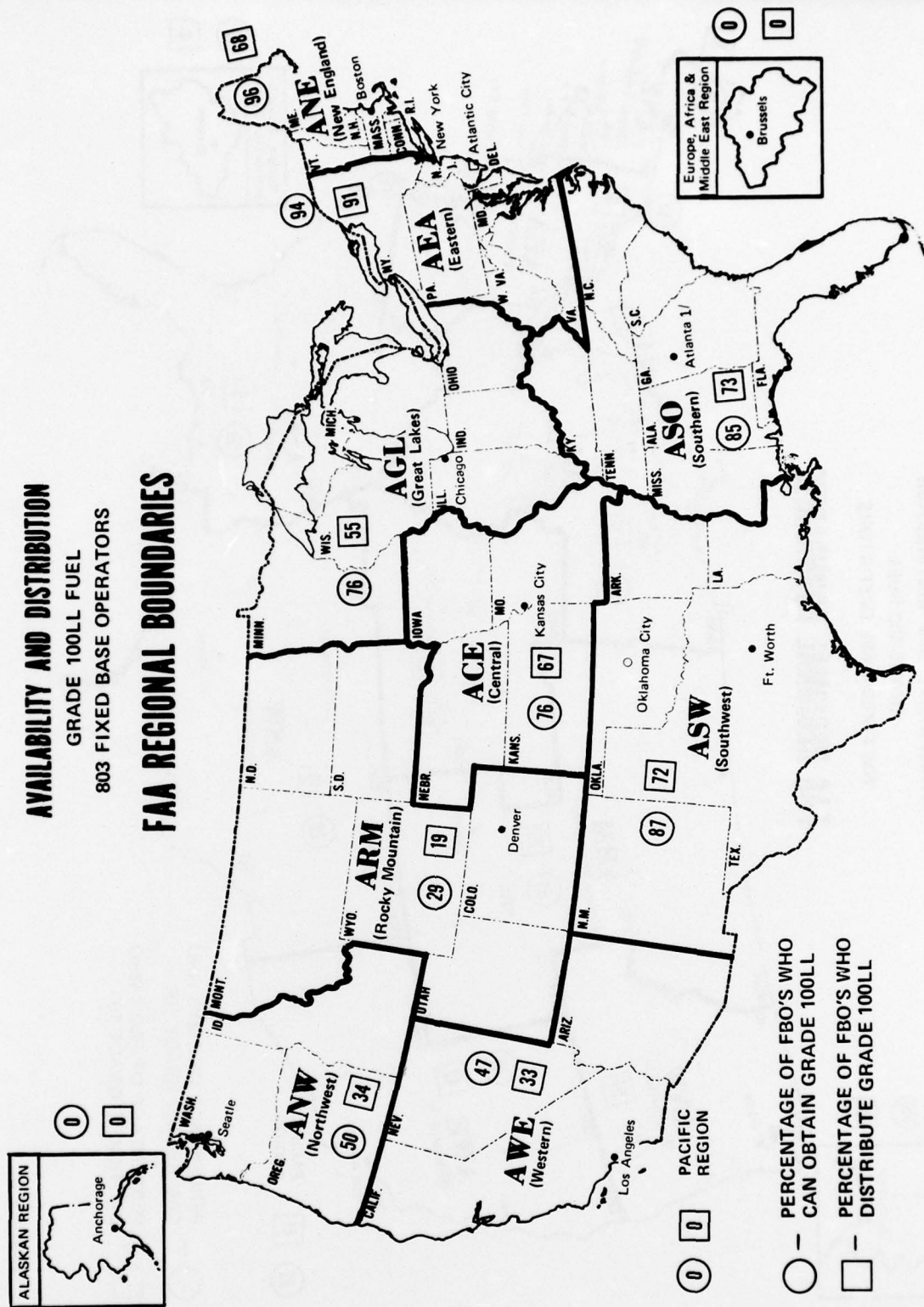


FIGURE 2

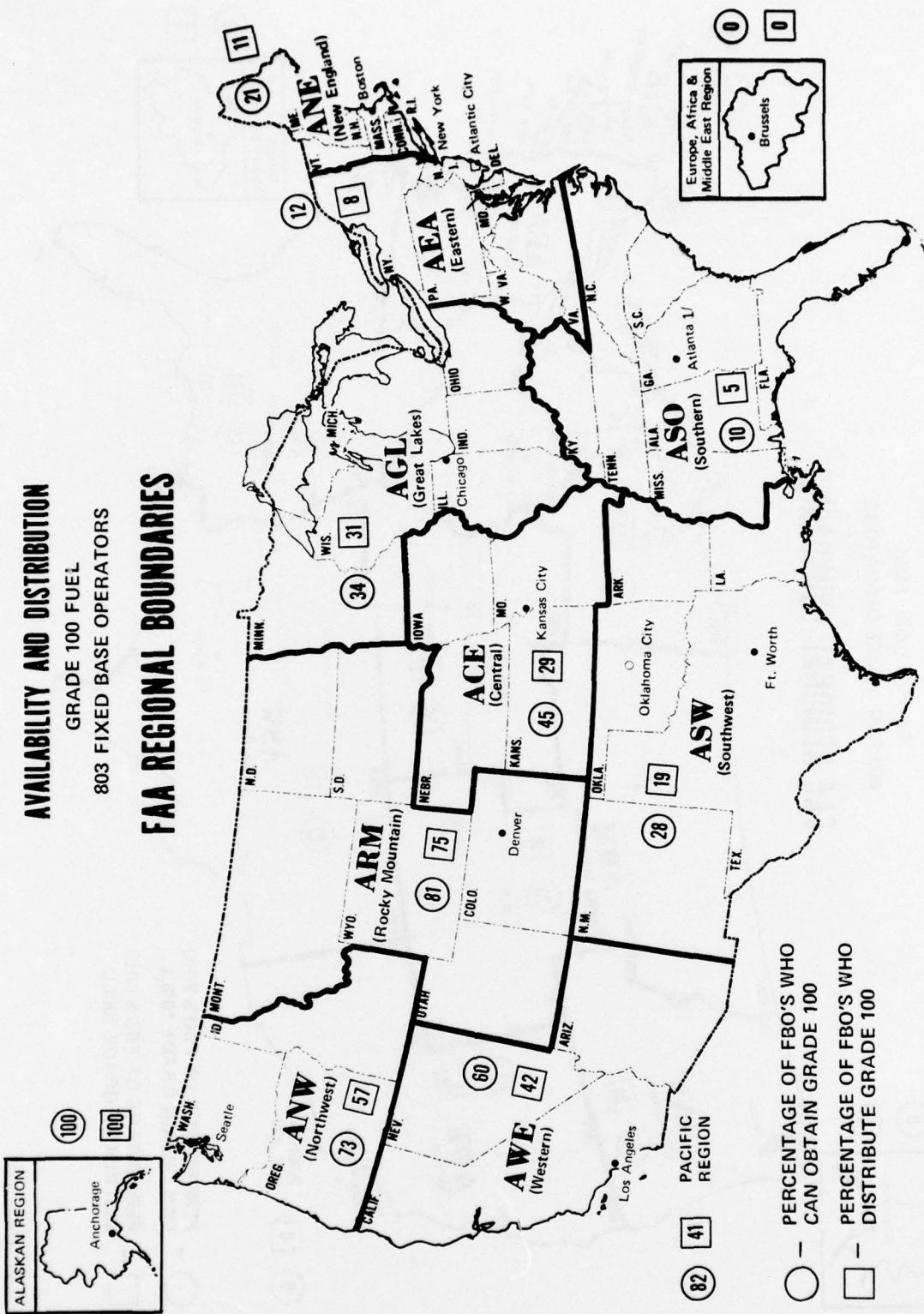


FIGURE 3

MAINTENANCE vs EXCLUSIVE FUEL USE

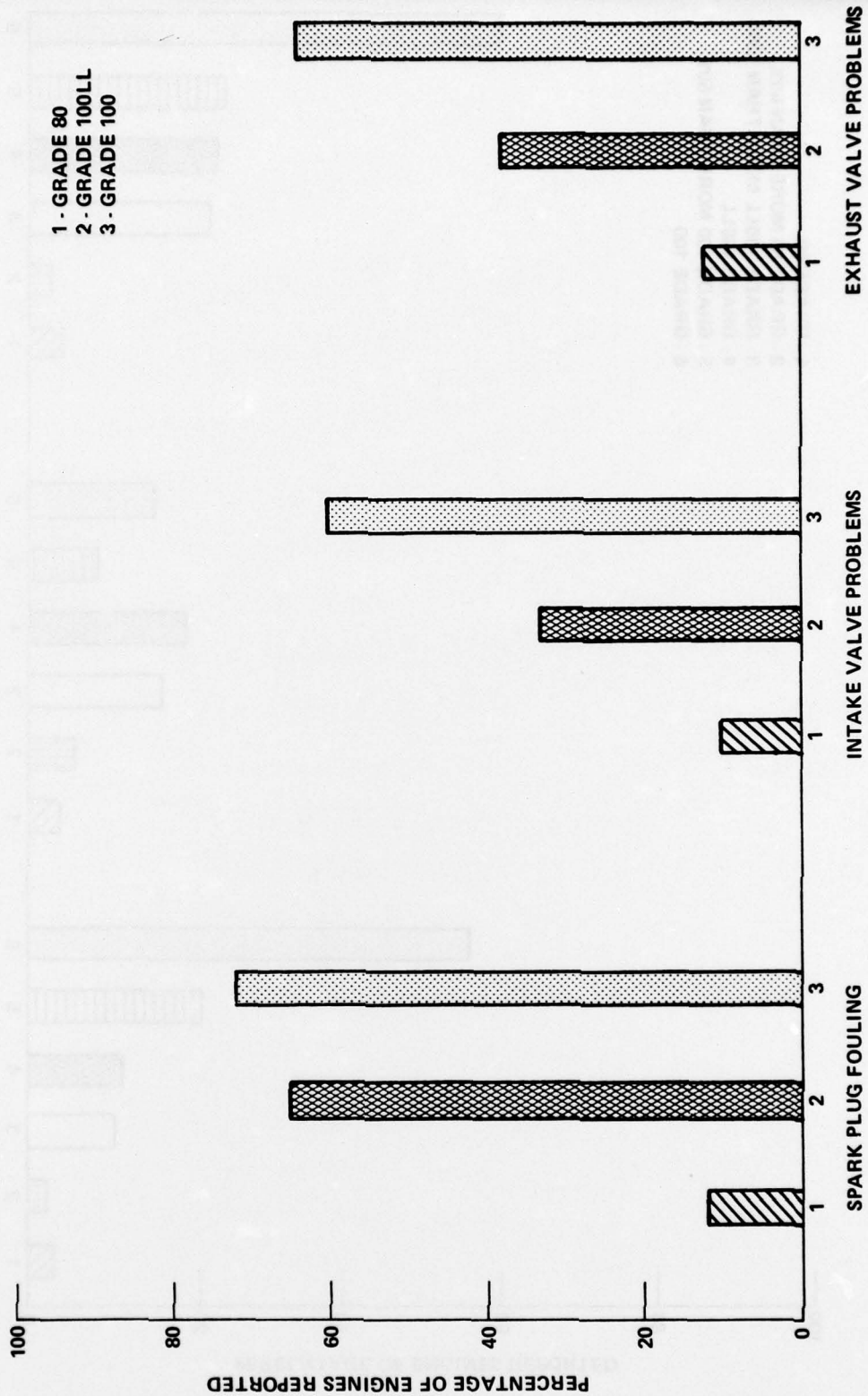


FIGURE 4

TEL INGESTION vs INTAKE VALVE MAINTENANCE

- 1 - GRADE 80
- 2 - GRADE 80 MORE THAN 50%
- 3 - GRADE 100LL MORE THAN 50%
- 4 - GRADE 100LL
- 5 - GRADE 100 MORE THAN 50%
- 6 - GRADE 100

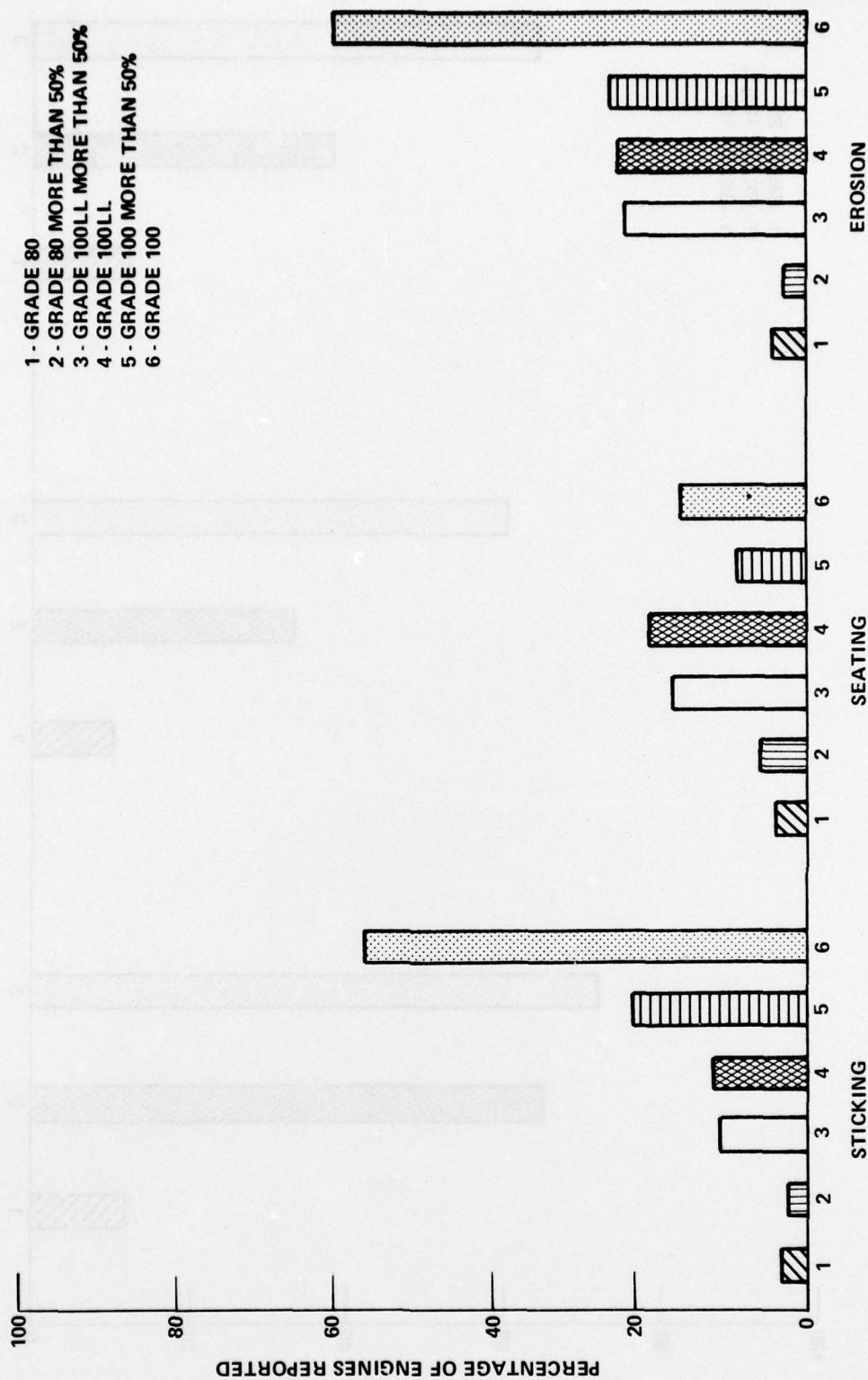


FIGURE 5

TEL INGESTION vs EXHAUST VALVE MAINTENANCE

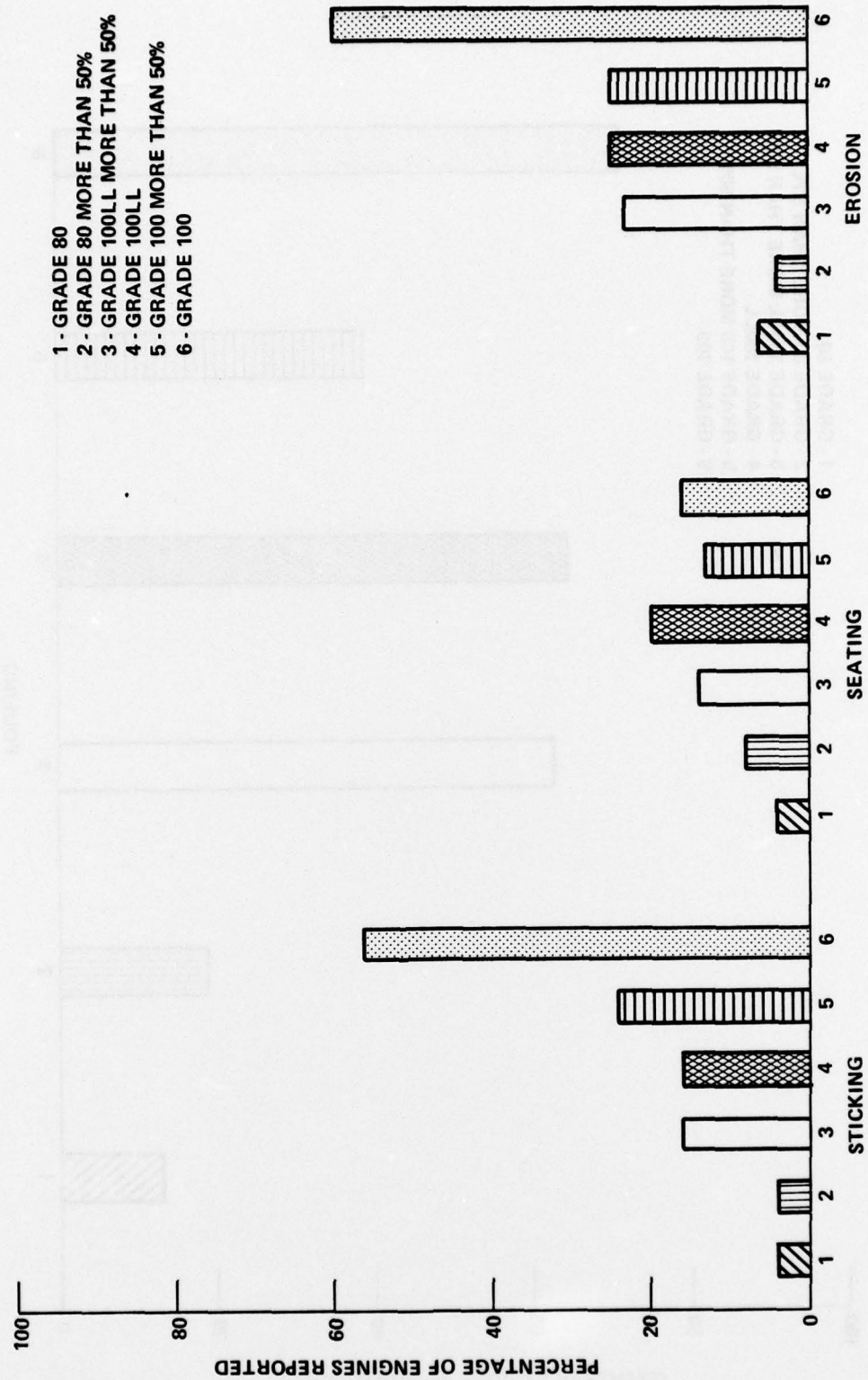


FIGURE 6

TEL INGESTION vs SPARK PLUG MAINTENANCE

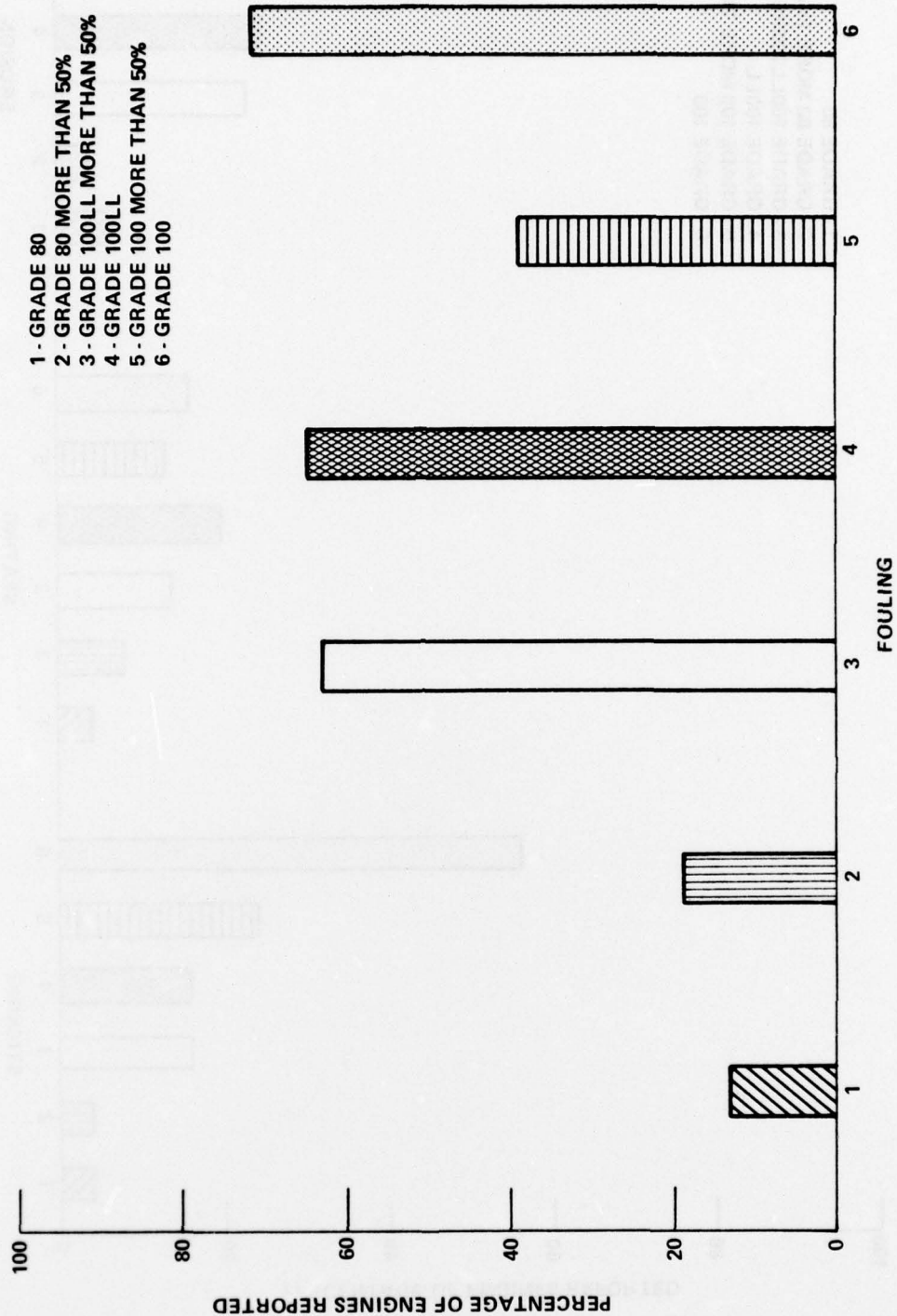


FIGURE 7

REASON FOR INTAKE VALVE MAINTENANCE WHEN USING MORE THAN 50% OF SPECIFIED FUEL

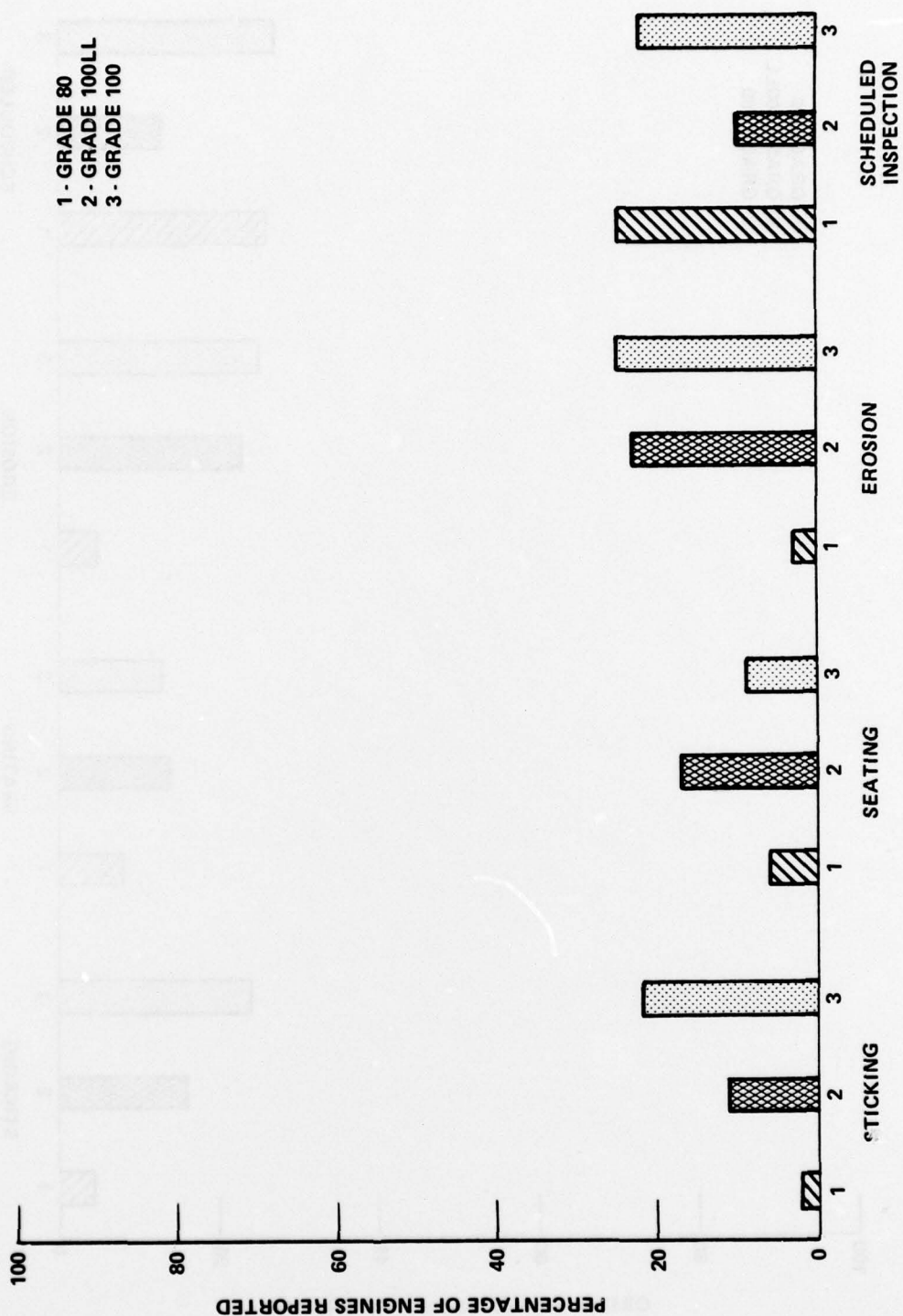


FIGURE 8

REASON FOR EXHAUST VALVE MAINTENANCE WHEN USING MORE THAN 50% OF SPECIFIED FUEL

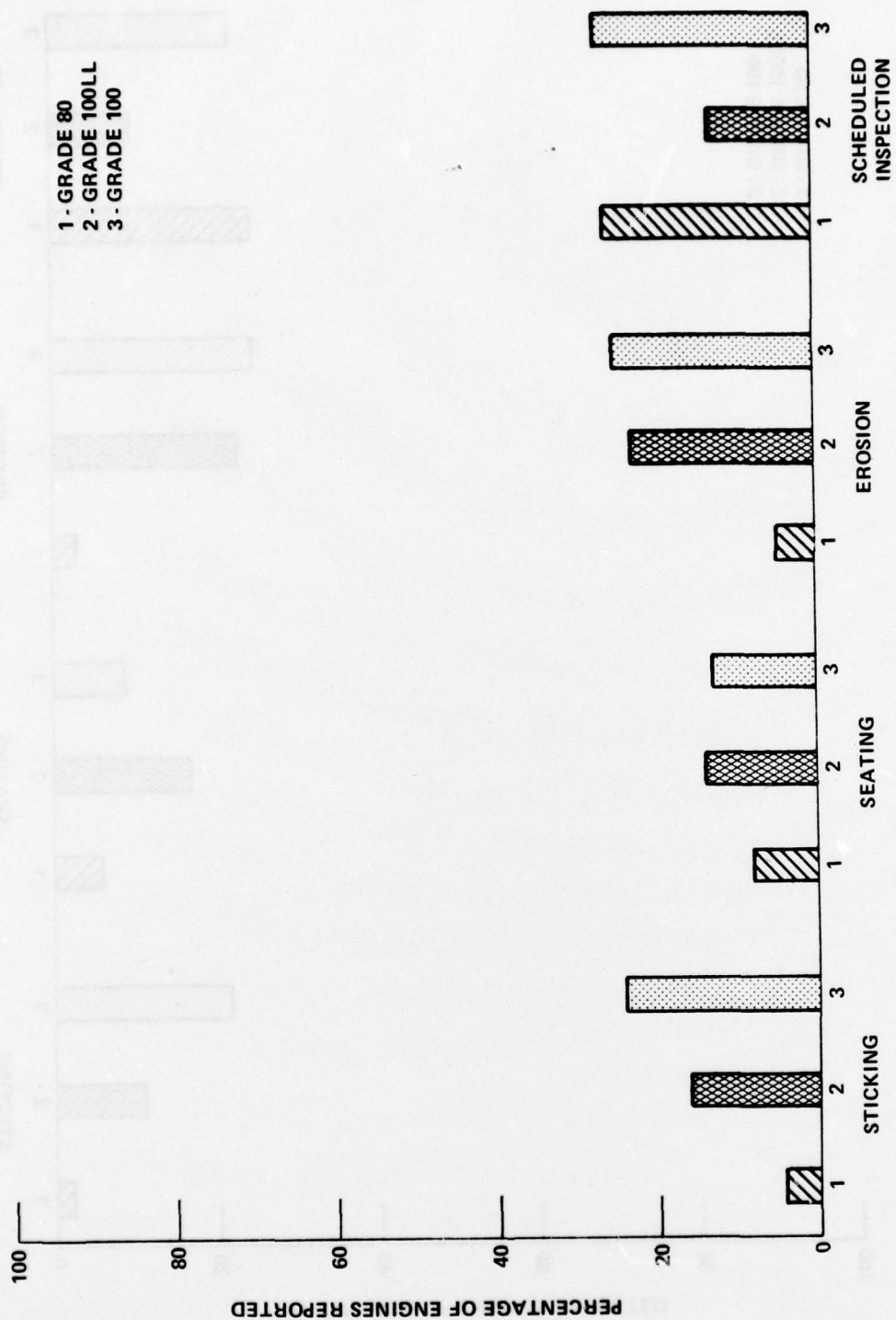


FIGURE 9

NOTICE**DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION**

N 8000.145

4/12/76

Cancellation

Date: 10/1/76

SUBJ: DIRECTED SAFETY INVESTIGATION (RIS: FS 8330-8): USE OF HIGHER LEADED
FUELS IN ENGINES ORIGINALLY CERTIFICATED FOR USE WITH GRADE 80 AVGAS.

1. PURPOSE. The primary purpose of this survey is to determine the extent of maintenance required as a result of using Grade 100LL or Grade 100 avgas in engines originally certificated for use with Grade 80 avgas. A secondary purpose is to determine the nationwide availability of Grades 80, 100LL, and 100 aviation gasoline.
2. DISTRIBUTION. This notice is distributed to Flight Standards offices, branch level and above; Washington Headquarters; regional offices; the Aeronautical Center; and Flight Standards and General Aviation District Offices (FSDO/GADO).
3. ACTION. Flight Standards and General Aviation District Office Inspectors are requested to personally contact as many Pilots/Owners/Operators (P/O/O) and Fixed Base Operators (FBO) as possible with various engines, in different locations which are intended for use with Grade 80 fuel; to provide a cross section of all types of operations, each office is to report on at least 20 aircraft. It is realized that some areas have only one grade of fuel available. However, every effort should be made to sample an equal number of aircraft using each type fuel. Therefore, as you conduct this survey, make sure you attempt to sample engines run on Grade 80 and engines run on higher leaded fuels, in order that we may make valid statistical comparisons. As you conduct the survey, make sure you use maintenance records and related documents, as opposed to relying on the memory of P/O/Os and FBOs.
4. EFFECTIVE DATE. Actions required by paragraphs 3 and 6 are effective immediately upon receipt of this notice.
5. BACKGROUND. The decreasing availability of Grade 80 avgas has caused P/O/Os and FBOs to use Grades 100LL and 100 avgas in engines originally certificated for use with Grade 80 avgas. This has led to reports of numerous maintenance difficulties, and has also led to an environment of rumor, speculation, and fear of safety problems.

Distribution: WRCFS-3; FFS-1,7 (wide); AAC-952 (80 cys); Initiated By: AAC-230/AFS-800
AAC-840 (1 cy)

4/12/76

RATING THE FUEL

Previous Commercial Fuel
Grades (ASTM Specification D910)

Grade	Color	Max.TEL ^{1/} ml/gal.
80/87	Red	0.5
91/98	Blue	2.0
100/130	Green	3.0
115/145	Purple	4.6

Current Commercial Fuel
Grades (ASTM Specification D910-75)

Grade	Color	Max.TEL ^{1/} ml/gal.
80	Red	0.5
100LL	Blue	2.0
100	Green	3.0
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^{1/} Maximum tetraethyl lead in milliliters per U.S. gallon.

6. DIRECTED SAFETY INVESTIGATION (DSI)

- a. The survey is to be completed and reports submitted to AAC-232 within 60 calendar days from receipt of this notice.
- b. Using the attached form, the inspector should complete all the items in the questionnaire by conducting personal interviews with the P/O/O or FBO. The information is essential to determine the existing norms for maintenance as they relate to operation with different grades of aviation gasolines.
- c. This investigation is intended to determine:
 - (1) The availability of Grade 80 fuel.
 - (2) The maintenance "norms" for engines run on the three different grades of fuel -- 80, 100LL and 100 avgas.
 - (3) If the local supplier has grade 80 fuel available even though the FBO does not store or dispense it.
- d. The time intervals recorded should represent the average hours the P/O/O or FBO has determined to be necessary or desirable to perform maintenance. The cause of maintenance may be malfunction, failure, preventive maintenance, or routine inspection (such as with spark plugs and/or valves). The time intervals recorded may or may not agree with recommended maintenance periods.

Par 5

- e. The investigation should be presented to the P/O/O or FBO as a "Maintenance Survey" to determine if there are any unusual maintenance problems being encountered in the field. In the interest of obtaining unbiased responses, the interviewer should not ask leading questions. He should remain objective and neutral during the questioning.
7. FORMS. Use the attached "Maintenance Survey" form (Appendix 1) to report all findings required by paragraph 6. Additional copies may be reproduced locally or obtained from the Maintenance Analysis Center, AAC-232.

J. A. Ferrarese
J. A. FERRARESE
Acting Director
Flight Standards Service

APPENDIX II
MAINTENANCE SURVEY
(use one form for each account)

1. SUBMITTER		LOCALITY (operating base)		District Office
FBO <input type="checkbox"/>	OTHER <input type="checkbox"/>	STATE	CITY	SYMBOL

2. FUEL - ALL SUBMITTERS -		- ALL SUBMITTERS -		- FBO ONLY -	
At your base, can you get:		Percentage of Use:		Do you dispense:	
Grade 80 (red)	yes <input type="checkbox"/> no <input type="checkbox"/>	Grade 80	% <input type="text"/>	Grade 80	yes <input type="checkbox"/> no <input type="checkbox"/>
Grade 100LL (blue)	yes <input type="checkbox"/> no <input type="checkbox"/>	Grade 100LL	% <input type="text"/>	Grade 100LL	yes <input type="checkbox"/> no <input type="checkbox"/>
Grade 100 (green)	yes <input type="checkbox"/> no <input type="checkbox"/>	Grade 100	% <input type="text"/>	Grade 100	yes <input type="checkbox"/> no <input type="checkbox"/>

3. EQUIPMENT (above fuel was used in)			total 100%	
Description			MONTHLY AVERAGE	
aircraft make	aircraft model	serial	op. hours	takeoffs
engine make	engine model	serial	engine TSO/TSN	
Enter serial number & engine hours for both engines on twin engine aircraft -			serial	engine TSO/TSN

4. OPERATIONS		Procedures Used	
Type Flying	%	Are most flights in cruise?	yes <input type="checkbox"/> no <input type="checkbox"/>
VFR Training	%	Are engines leaned in flight?	yes <input type="checkbox"/> no <input type="checkbox"/>
IFR Training	%	Are engines leaned on ground?	yes <input type="checkbox"/> no <input type="checkbox"/>
Cross Country	%	Is carburetor heat used on ground? (other than preflight check)	yes <input type="checkbox"/> no <input type="checkbox"/>
Other	%		

5. MAINTENANCE		total 100%	
Engine Oil System		Engine Oil Type	change
Oil filter installed?	yes <input type="checkbox"/> no <input type="checkbox"/>	Straight Mineral <input type="checkbox"/>	Other <input type="checkbox"/>
Exhaust Valves		Reason for exhaust valve maint	
Are improved valves installed?	yes <input type="checkbox"/> no <input type="checkbox"/>	Sticking <input type="checkbox"/>	Erosion <input type="checkbox"/>
(If yes, is maintenance reduced)	<input type="checkbox"/>	Seating <input type="checkbox"/>	Sched Insp <input type="checkbox"/>
Intake Valves		Reason for intake valve maint	
Are improved valves installed?	yes <input type="checkbox"/> no <input type="checkbox"/>	Sticking <input type="checkbox"/>	Erosion <input type="checkbox"/>
(If yes, is maintenance reduced)	<input type="checkbox"/>	Seating <input type="checkbox"/>	Sched Insp <input type="checkbox"/>
Spark Plugs		Reason for plug maintenance	
part no.	hours	Rotate (top/bottom) <input type="checkbox"/>	Sched Clean or Replace <input type="checkbox"/>
Fouled <input type="checkbox"/>			

6. COMMENTS-

--

- Instructions on back -

4/12/76

Instructions for Completing Form

<u>ITEM</u>	<u>ENTRY</u>
1. Submitter	Check FBO block when submitter is a "Fixed Base Operator." Check other block for all remaining submitters.
Locality	Enter State & City where operating base is located.
District Office	Enter appropriate FAA District Office symbol.
2. Fuel	
At your base, can you get	Check all appropriate blocks. FBO's indicate the grades of fuel available to you even though you do not handle or dispense them.
Percentage of use	Enter appropriate percentages of fuel used in equipment described under item 3.
Do you dispense	FBO's only - Check appropriate blocks for the grades of fuel you provide/dispense.

FBO's with no operating equipment need not complete the remainder of the form.

The above questions are designed to determine what grades of fuel an FBO could dispense if he chose to and what he actually does dispense.

3. Equipment	
Description	Enter make, model and serial number of the aircraft and each engine that the fuel described in item 2 was used in. Enter the average number of operating hours and takeoffs conducted each month. Enter appropriate engine "Time since overhaul" or "Time since new" in whole hours.
4. Operations	
Type Flying	Enter appropriate percentages for each type flying.
Procedures used	Check appropriate blocks.
5. Maintenance	
Engine oil system	Check appropriate filter installation block. Enter the replacement interval in whole hours when a filter is installed.
Engine oil type	Check appropriate type oil block and enter the oil change interval in whole hours.
Exhaust Valves & Intake Valves	Check yes block if improved valves have been installed for use with higher lead fuels. If lower maintenance has resulted from using the improved valve, check yes block. When unable to respond to type valves installed check question block. However, complete all reasons for valve maintenance in any event. Enter appropriate maintenance interval in whole hours.
Spark Plugs	Enter part number of spark plugs being utilized. Check appropriate blocks for spark plug maintenance. Enter appropriate maintenance intervals in whole hours.